

# Claims

- [c1] 1. A spindle positioning apparatus for a robotic manipulator comprising:  
a mounting plate assembly attached to the robotic manipulator;  
a first spindle disposed on the mounting plate assembly in a fixed position;  
a second spindle disposed on the mounting plate assembly and movable with respect to the first spindle;  
and  
an actuator mechanism adapted to position the second spindle with respect to the first spindle.
- [c2] 2. The apparatus of claim 1 wherein the mounting plate assembly includes a fixed plate adapted to receive the first spindle and disposed proximate the robotic manipulator and a movable plate adapted to receive the second spindle and movably attached to the fixed plate.
- [c3] 3. The apparatus of claim 2 wherein the first spindle extends through the fixed plate and the second spindle extends through the movable plate.
- [c4] 4. The apparatus of claim 2 wherein the actuator mecha-

nism is disposed proximate the mounting plate assembly.

- [c5] 5. The apparatus of claim 4 wherein the actuator mechanism further comprises a ball screw assembly having a ball nut and a ball screw, and a servo motor adapted to rotate the ball screw to actuate the ball nut.
- [c6] 6. The apparatus of claim 5 wherein the ball nut is attached to the movable plate and the ball screw is attached to the fixed plate.
- [c7] 7. The assembly of claim 1 wherein the first spindle has a first axis of rotation, the second spindle has a second axis of rotation, and a distance between the first and second axes of rotation is in the range of 75 mm to 1400 mm.
- [c8] 8. The apparatus of claim 1 wherein the first spindle is adapted to rotate about a first axis of rotation, the second spindle is adapted to rotate about a second axis of rotation, and the first and second axes of rotation are disposed parallel each other.
- [c9] 9. A multi-spindle positioning assembly comprising:  
a multi-axis robot having a manipulator arm; and  
a spindle positioning apparatus including:  
a first mounting plate attached to the manipulator arm

and having a first opening;  
a second mounting plate movably attached to the first mounting plate and having a second opening;  
a first spindle extending through the first opening and attached to the first mounting plate;  
a second spindle extending through the second opening and attached to the second mounting plate; and  
an actuator mechanism adapted to position the second spindle with respect to the first spindle.

[c10] 10. The assembly of claim 9 further comprising a track disposed proximate the first mounting plate and adapted to movably receive the second mounting plate.

[c11] 11. The assembly of claim 9 wherein the actuator mechanism further comprises a ball screw assembly having a ball nut and a ball screw, and a servo motor adapted to rotate the ball screw to actuate the ball nut.

[c12] 12. The assembly of claim 11 wherein the ball screw is attached to the first mounting plate and the ball nut is attached to the second mounting plate.

[c13] 13. The assembly of claim 11 wherein the first spindle has a first axis of rotation, the second spindle has a second axis of rotation, and a distance between the first and second axes of rotation is in the range of 75 mm to

1400 mm.

[c14] 14. The assembly of claim 9 wherein the first and second spindles include first and second tools, respectively, each adapted to engage a threaded part.

[c15] 15. A method for applying torque to a set of threaded parts with a spindle positioning apparatus disposed on a robotic manipulator, the spindle positioning apparatus including first and second spindle assemblies each adapted to engage a threaded part and having first and second axes of rotation, respectively, the second spindle assembly being movable with respect to the first spindle assembly, the method comprising:

selecting a subset of the set of threaded parts;

determining a center line distance between the threaded parts in the subset;

moving the second spindle assembly such that the first and second axes of rotation are separated by an amount equal to the center line distance;

positioning the spindle positioning apparatus with the robotic manipulator such that the first and second spindle assemblies are disposed proximate the subset of threaded parts;

rotating the first and second spindle assemblies to apply torque to the subset of threaded parts; and

repeating the selecting step for additional subsets of

threaded parts until all of the threaded parts in the set are selected.

[c16] 16. The method of claim 15 wherein a first subset selected from the set of threaded parts is disposed proximate a center of a workpiece.

[c17] 17. The method of claim 16 wherein at least one part in the subset of threaded parts for a current iteration is spaced further from the center of the workpiece than a part in the subset of threaded parts selected for a prior iteration.

[c18] 18. The method of claim 16 wherein a last subset selected from the set of threaded parts includes a part disposed furthest from the center of the workpiece.

[c19] 19. The method of claim 15 wherein the threaded parts are threaded bolts and the workpiece is a cam cover.

[c20] 20. The method of claim 15 wherein the threaded parts are spark plugs and the workpiece is an engine.